Using ADC on Firebird-V Robot

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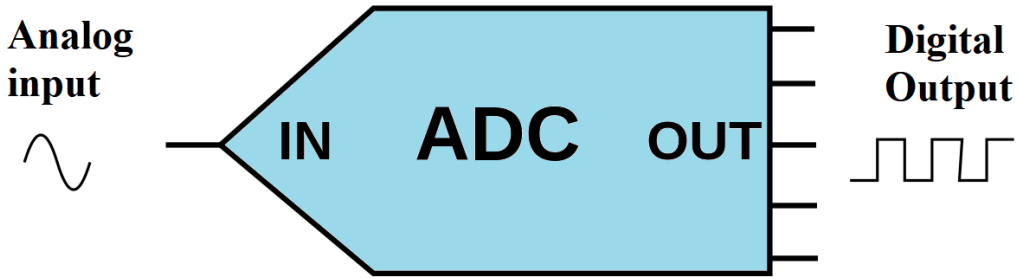
Agenda for Discussion

1. Analog to Digital Conversion
   - What is an ADC
   - Steps in ADC
   - Need for ADC
   - ADC of ATmega2560
   - ADC Channels
2. Coding ADC
   - ADC Initialization
   - ADCSRA
   - ADCSRB
   - ADMUX
   - ACSR
   - Algorithm for ADC

What is an ADC

What is an ADC

- Converts a signal from analog (continuous) to digital form.



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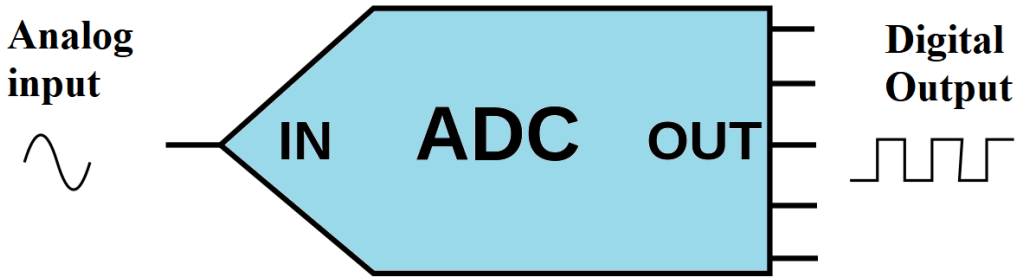

- To process the data using processor, we need to convert the analog signals to the digital signals.

Steps in ADC

Steps involved in A-D conversion are:

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- **Sampling**
- Quantization
- Encoding

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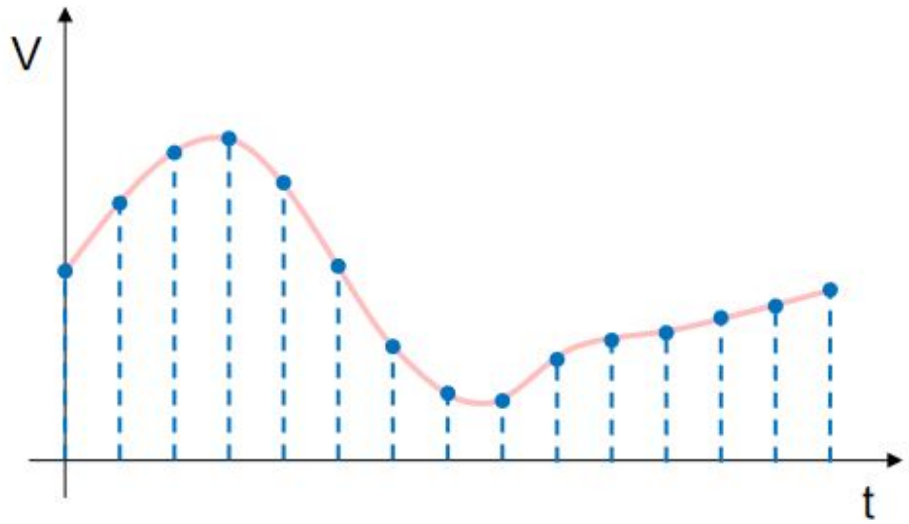

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Steps involved in A-D conversion are:

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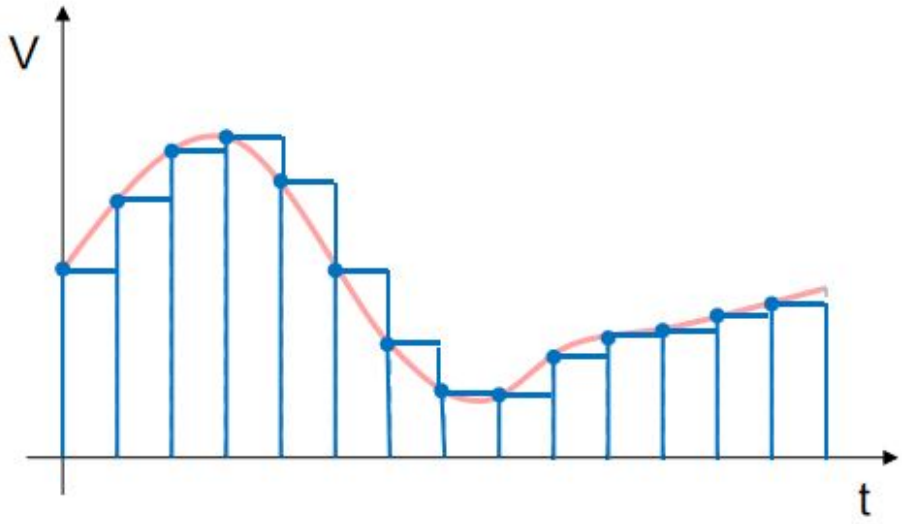

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Steps involved in A-D conversion are:

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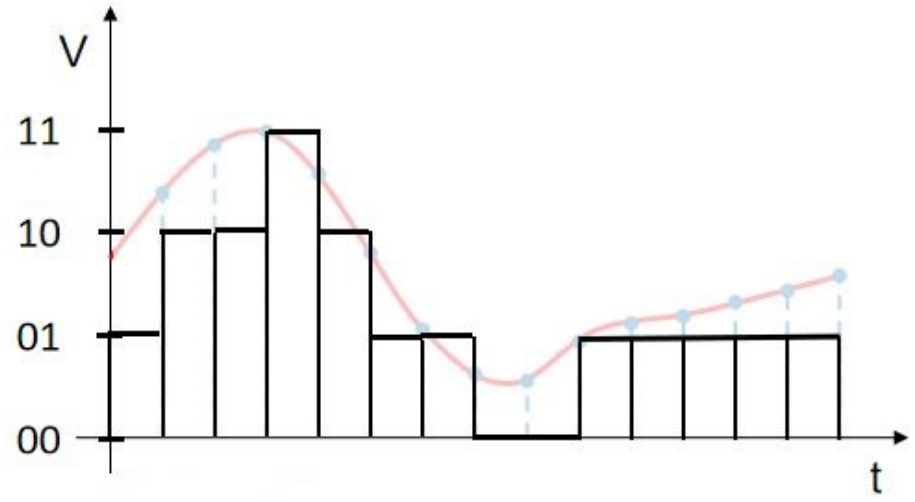

Need for ADC

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- IR Proximity sensors

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- Sharp IR Range sensors

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- Sharp IR Range sensors
- White line sensors

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- Battery voltage sensor

Need for ADC

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- Sharp IR Range sensors
- White line sensors
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- etc..

In-Built ADC of ATmega2560

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- Free Running or Single Conversion Mode

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- 0 - VCC ADC Input Voltage Range
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- Selectable 2.56V or 1.1V ADC Reference Voltage
- Free Running or Single Conversion Mode
- Interrupt on ADC Conversion Complete

ADC Channels

Pin No.	Pin Name	Description
97	PF0/ADC0	ADC input for Battery Voltage Monitoring
96	PF1/ADC1	ADC input for White Line Sensor 3(Right)
95	PF2/ADC2	ADC input for White Line Sensor 2(Center)
94	PF3/ADC3	ADC input for White Line Sensor 1(Left)
93	PF4/ADC4	ADC input for IR proximity analog sensor 1
92	PF5/ADC5	ADC input for IR proximity analog sensor 2
91	PF6/ADC6	ADC input for IR proximity analog sensor 3
90	PF7/ADC7	ADC input for IR proximity analog sensor 4
89	PK0/ADC8	ADC input for IR proximity analog sensor 5
88	PK1/ADC9	ADC input for Sharp IR range sensor 1
87	PK2/ADC10	ADC input for Sharp IR range sensor 2
86	PK3/ADC11	ADC input for Sharp IR range sensor 3
85	PK4/ADC12	ADC input for Sharp IR range sensor 4
84	PK5/ADC13	ADC input for Sharp IR range sensor 5
83	PK6/ADC14	ADC input for Servo Pod 1
82	PK7/ADC15	ADC input for Servo Pod 2

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95	PF2/ADC2	ADC input for White Line Sensor 2(Center)
94	PF3/ADC3	ADC input for White Line Sensor 1(Left)
93	PF4/ADC4	ADC input for IR proximity analog sensor 1
92	PF5/ADC5	ADC input for IR proximity analog sensor 2
91	PF6/ADC6	ADC input for IR proximity analog sensor 3
90	PF7/ADC7	ADC input for IR proximity analog sensor 4
89	PK0/ADC8	ADC input for IR proximity analog sensor 5
88	PK1/ADC9	ADC input for Sharp IR range sensor 1
87	PK2/ADC10	ADC input for Sharp IR range sensor 2
86	PK3/ADC11	ADC input for Sharp IR range sensor 3
85	PK4/ADC12	ADC input for Sharp IR range sensor 4
84	PK5/ADC13	ADC input for Sharp IR range sensor 5
83	PK6/ADC14	ADC input for Servo Pod 1
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ADC Initialization

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3. ADMUX - ADC Multiplexer Selection Register

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4. ACSR - Analog Comparator Control and Status Register

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  These registers are:

  1. ADCSRA - ADC Control and Status Register A
  2. ADCSRB - ADC Control and Status Register B
  3. ADMUX - ADC Multiplexer Selection Register
  4. ACSR - Analog Comparator Control and Status Register

- All these registers are 8 Bit

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	1

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	1
0	ADPS0	ADC Prescaler Select Bits	

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	1
0	ADPS0	ADC Prescaler Select Bits	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	1
0	ADPS0	ADC Prescaler Select Bits	0

ADCSRA- ADC Control and Status Register A

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	ADEN	ADC Enable	1
6	ADSC	ADC Start Conversion	0
5	ADATE	ADC Auto Trigger Enable	0
4	ADIF	ADC Interrupt Flag	0
3	ADIE	ADC Interrupt Enable	0
2	ADPS2	ADC Prescaler Select Bits	1
1	ADPS1	ADC Prescaler Select Bits	1
0	ADPS0	ADC Prescaler Select Bits	0

ADC Prescaler Selection Bit

ADC Prescaler Selection Bit

Table 26-5. ADC Prescaler Selections

ADPS2	ADPS1	ADPS0	Division Factor
0	0	0	2
0	0	1	2
0	1	0	4
0	1	1	8
1	0	0	16
1	0	1	32
1	1	0	64
1	1	1	128

ADC clock frequency = (F_CPU / Division Factor)
= 14745600 / 64
= 230 kHz (approx.)

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

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Bit	Symbol	Description	Bit Value

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	

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ADCSRB- ADC Control and Status Register B

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Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-
3	MUX5	ADC Channel selection bit-5	

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-
3	MUX5	ADC Channel selection bit-5	0

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-
3	MUX5	ADC Channel selection bit-5	0
2	ADTS2	ADC Auto Trigger Source Bits	0
1	ADTS1	ADC Auto Trigger Source Bits	0
0	ADTS0	ADC Auto Trigger Source Bits	0

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-
3	MUX5	ADC Channel selection bit-5	0
2	ADTS2	ADC Auto Trigger Source Bits	0
1	ADTS1	ADC Auto Trigger Source Bits	0
0	ADTS0	ADC Auto Trigger Source Bits	0

ADCSRB- ADC Control and Status Register B

This register is used to control ADC operation

Bit	Symbol	Description	Bit Value
7	-	Reserved Bit	-
6	ACME	Analog Comparator Multiplexer Enable	0
5	-	Reserved Bit	-
4	-	Reserved Bit	-
3	MUX5	ADC Channel selection bit-5	0
2	ADTS2	ADC Auto Trigger Source Bits	0
1	ADTS1	ADC Auto Trigger Source Bits	0
0	ADTS0	ADC Auto Trigger Source Bits	0

Table 26-6. ADC Auto Trigger Source Selections

ADTS2	ADTS1	ADTS0	Trigger Source
0	0	0	Free Running mode
0	0	1	Analog Comparator
0	1	0	External Interrupt Request 0
0	1	1	Timer/Counter0 Compare Match A
1	0	0	Timer/Counter0 Overflow
1	0	1	Timer/Counter1 Compare Match B
1	1	0	Timer/Counter1 Overflow
1	1	1	Timer/Counter1 Capture Event

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

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Bit	Symbol	Description	Bit Value

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	1

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	1
4	MUX4	ADC Channel selection bit-4	

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	1
4	MUX4	ADC Channel selection bit-4	0
3	MUX3	ADC Channel selection bit-3	0
2	MUX2	ADC Channel selection bit-2	0
1	MUX1	ADC Channel selection bit-1	0
0	MUX0	ADC Channel selection bit-0	0

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	1
4	MUX4	ADC Channel selection bit-4	0
3	MUX3	ADC Channel selection bit-3	0
2	MUX2	ADC Channel selection bit-2	0
1	MUX1	ADC Channel selection bit-1	0
0	MUX0	ADC Channel selection bit-0	0

ADMUX - ADC Multiplexer Selection Register

This register is used to select reference voltage and ADC channel

Bit	Symbol	Description	Bit Value
7	REFS1	Reference Selection Bit	0
6	REFS0	Reference Selection Bit	1
5	ADLAR	ADC Left Adjust Result	1
4	MUX4	ADC Channel selection bit-4	0
3	MUX3	ADC Channel selection bit-3	0
2	MUX2	ADC Channel selection bit-2	0
1	MUX1	ADC Channel selection bit-1	0
0	MUX0	ADC Channel selection bit-0	0

ADC Reference Voltage Selection Bit

ADC Reference Voltage Selection Bit

Table 26-3. Voltage Reference Selections for ADC

REFS1	REFS0	Voltage Reference Selection(1)
0	0	AREF, Internal V_{REF} turned off
0	1	AVCC with external capacitor at AREF pin
1	0	Internal 1.1V Voltage Reference with external capacitor at AREF pin
1	1	Internal 2.56V Voltage Reference with external capacitor at AREF pin

ADC Left Adjustment Bit

ADC Left Adjustment Bit

The ADC Data Register – ADCL and ADCH

ADLAR = 0

Bit	15	14	13	12	11	10	9	8	
	–	–	–	–	–	–	ADC9	ADC8	ADCH
	ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0	ADCL
	7	6	5	4	3	2	1	0	
Read/Write	R	R	R	R	R	R	R	R	
	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	

ADLAR = 1

Bit	15	14	13	12	11	10	9	8	
	ADC9	ADC8	ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADCH
	ADC1	ADC0	–	–	–	–	–	–	ADCL
	7	6	5	4	3	2	1	0	
Read/Write	R	R	R	R	R	R	R	R	
	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	

ADMUX5:0 Channel Selection

ADMUX5:0 Channel Selection

MUX5:0	ADC Channel
000000	ADC0
000001	ADC1
000010	ADC2
000011	ADC3
000100	ADC4
000101	ADC5
000110	ADC6
000111	ADC7

ADMUX5:0 Channel Selection

MUX5:0	ADC Channel
000000	ADC0
000001	ADC1
000010	ADC2
000011	ADC3
000100	ADC4
000101	ADC5
000110	ADC6
000111	ADC7

ADMUX5:0 Channel Selection

MUX5:0	ADC Channel
000000	ADC0
000001	ADC1
000010	ADC2
000011	ADC3
000100	ADC4
000101	ADC5
000110	ADC6
000111	ADC7

MUX5:0	ADC Channel
100000	ADC8
100001	ADC9
100010	ADC10
100011	ADC11
100100	ADC12
100101	ADC13
100110	ADC14
100111	ADC15

ACSR - Analog Comparator Control and Status Register

This register is used for Analog Comparator

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This register is used for Analog Comparator

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7	ACD	Analog Comparator Disable	

ACSR - Analog Comparator Control and Status Register

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7	ACD	Analog Comparator Disable	1
6	ACBG	Analog Comparator Bandgap Select	0
5	ACO	Analog Comparator Output	0
4	ACI	Analog Comparator Interrupt Flag	0
3	ACIE	Analog Comparator Interrupt Enable	0
2	ACIC	Analog Comparator Input Capture Enable	0
1	ACIS1	Analog Comparator Interrupt Mode Select	0
0	ACIS0	Analog Comparator Interrupt Mode Select	0

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Thank You!